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Environmental Radiation Program

STATE OF WASHINGTON DEPARTMENT OF HEALTH
INTERIM REGULATORY GUIDANCE

HANFORD GUIDANCE FOR RADIOLOGICAL CLEANUP

November 1997
Rev 1.

Washington State Department of Health

Environmental Health Programs

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ERRATA (March 2000)

- previous hardcopy incorrectly gives the units of "Mass Loading for Inhalation" as grams per cubic centimeter. This appears in Appendix B, on page 13 under RO17; it is correctly stated as grams per cubic meter in this electronic version.
- The phone and fax numbers are no longer current in the printed versions of this publication. The current phone number is 360-236-3251 for Debra McBaugh, and the appropriate FAX number is 360-236-2255.

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PURPOSE

As designated in Chapter 70.98 RCW and through a Memorandum of Understanding between the Washington Department of Ecology (Ecology) and the Washington State Department of Health (DOH) (WDOH 1994), DOH is recognized as the primary state agency for protection of human health and the environment from ionizing radiation, and DOH regulates the cleanup of radioactive wastes and facilities under Chapter 70.98 RCW. Under the Hanford Federal Facility Agreement and Consent Order (TPA), Ecology is the state agency designated to oversee Hanford cleanup. DOH will review and provide recommendations to Ecology on radiological aspects of Hanford cleanup. This interim radiological guidance describes policy and procedures that DOH will use in this process. For facilities regulated by a state or federal regulation containing an applicable health-based cleanup or closure standard specific for radionuclides, DOH may upon further analysis determine that standard to be more appropriate.

DOH has not issued an environmental radiation standard through the state rulemaking process; therefore, the following interim Radiological Guidance (RG) is issued to define the state radiological criteria which must be met before Hanford land or property can be released for public use. It also describes the procedure the Department of Health will use in evaluating levels of residual radioactivity following Hanford cleanup and deactivation and decommissioning (D&D). The motivation for establishing an interim RG is the current need for consistent radiological standards for environmental cleanup at the Hanford sites, since there are no applicable state or federal regulations for radiological cleanup.

In the development, selection, and implementation of CERCLA cleanup actions at Hanford, this interim RG is expected to be evaluated as a "to be considered" requirement consistent with the National Contingency Plan *Subpart E - Hazardous Substance Response* and CERCLA *Section 121 - Cleanup Standards*. This RG is consistent with the draft proposed guidelines published by the EPA (40 CFR Part 196) and the NRC (10 CFR Part 20) (Proposed Rule 1994). This RG, when promulgated, will be identified by the state of Washington as an Applicable or Relevant and Appropriate Requirement (ARAR) for the development, selection, and implementation of CERCLA cleanup actions at Hanford.

POLICY

This RG adopts dose-based guidance for the remediation of radiologically contaminated soil, groundwater, materials, and structures at the Hanford Site that will allow sites and facilities to be released for public use.

The dose limit for release of a site is 15 mrem/y (0.15 mSv/y) Total Effective Dose Equivalent (TEDE) to a reasonable maximally exposed (RME) individual, from residual radioactivity which is distinguishable from background radiation levels for 1000 years after completion of the cleanup. This limit applies to the sum of radiation exposure from all pathways by which a person could be exposed to residual radioactivity. EPA describes the reasonable maximum exposure concept as an approach which uses standardized exposure pathways and default exposure factor values to calculate maximum reasonable estimates of contaminant intake and risk for individuals in an exposed population.

Institutional controls, alternate land uses, and engineered barriers may be utilized as methods of limiting exposure by eliminating or controlling exposure pathways. Restriction on land use must be recorded through deed or other restrictions. This RG limit will apply at the time that land or facilities are released for public use.

In addition to the major sites identified in the TPA, there are numerous facilities, structures, equipment, and building materials containing surface or volume contamination that will be remediated through the D&D process. These activities are not covered by the TPA but are being addressed through U.S. Department of Energy orders. This RG applies to D&D activities where the end result will be the release of land, facilities or property for public use.

BASIS

An annual dose limit of 15 mrem was chosen to be compatible with the Interim Remedial Action Objective in the 100 Area Record of Decision, which is the guidance being used for current Hanford cleanup under the TPA. It is understood that federal standards, when in place, may be higher but are unlikely to be lower. This guidance will be reviewed and revised as appropriate when applicable federal standards are issued.

The existing state of Washington limit for radiation exposure to mem-bers of the public from licensed or registered operations as described in WAC 246-221-060, *Dose Limits for Members of the Public*, is 100 mrem per year. In 1993, the National Council on Radiation Protection and Measurements issued Report No. 116, *Limitations of Exposure to Ionizing Radiation* (NCRP 1993). This report updates the NCRP recom-mendations following the publication by national and inter-national organizations of the most recent data on the biological effects of ioniz-ing radiation. The report recommends that for continuous (or frequent) exposure, the annual effective dose not exceed 100 mrem. The NCRP also recommends that no single source or set of sources under one control should result in an individual being exposed to more than 25 percent of the annual effective dose limit of 100 mrem; that is, 25 mrem. In 1994, the U.S. Environmental Protection Agency proposed a draft cleanup standard for public comment that contained an annual dose standard of 15 mrem. The Nuclear Regulatory Commission proposed a 15 mrem standard in 1994, and in April 1997, revised their proposed final rule to 25 mrem. No federal standard has yet been issued.

PROCEDURE

Background

At Hanford, the cleanup process is defined by the Federal Facilities Agreement and Consent Order (TPA 1989), also known as the Tri-Party Agreement. Site-specific goals that define the extent of cleanup necessary to achieve the specified level of remediation at a site are listed as Remedial Action Objectives (RAOs) in a CERCLA Record of Decision. The Department of Health will assist in the incorporation of radiological cleanup guidance into the RAOs and RODs. Achievement of the RAOs is realized through compliance with governing federal and state statutes such as CERCLA and MTCA, as well as proposed and promulgated directives and guidances such as this RG.

The process of determining if these objectives have been met will involve field and laboratory measurements of radioactivity at the site and modeling of expected doses based on proposed land uses and the site-specific physical parameters. This section describes the procedure to be used to determine if the limits defined in this Regulatory Guide, which will be incorporated into Remedial Action Objectives, have been met.

The dose standard in this guidance is a dose of 15 mrem/y above background levels. Background radiation refers to the local area and includes:

(1) concentrations of naturally occurring radionuclides,

(2) cosmic radiation, and

(3) radionuclides of anthropogenic origin which have been globally dispersed and are present at low concentrations (such as fallout from the testing of nuclear weapons).

Local area background is the external radiation and environmental radionuclide concentrations in the area near Hanford but not contaminated by past Hanford activities. DOE 1995 and DOE 1996 describe the background concentrations in soil that are the major contributors to background dose.

The 90th percentile background radionuclide concentrations shall be used when subtracting the background contribution from measurements made at a site. Soil background concentration subtraction shall be performed on a radionuclide-specific basis.

Doses caused by radon-222 and its respective decay products are not included in the dose limit. Enhanced levels of radon-222 are from the decay of radium-226 and this radionuclide was not brought onto the Hanford site as part of its nuclear operations. Processing of uranium that separates radium-226 and other daughter products from natural uranium was conducted at other U.S. DOE sites.

Monitoring

Radiation monitoring is a basic part of the cleanup process. Excavation and removal activities will include monitoring to guide excavation and determine when cleanup is complete. Monitoring of the residual radioactivity at a site after remediation must be conducted in a manner that will provide quality data to evaluate if a site meets cleanup criteria. The specific monitoring procedures, equipment, and instrumentation to be used are left to the discretion of the U.S. DOE; however, the following criteria must be met when monitoring the final status of a site:

- Measurement methods must have a minimum detectable activity (MDA) that is less than the amount that will result in a 15 mrem/y dose based on proposed land use scenarios.

- The entire site must be monitored using a method similar to the grid pattern described in NUREG-5849, Section 4.0.

- Monitoring must address all radioactive contaminants that are identified as Contaminants of Potential Concern (COPC) in the ROD or as revised in the Sampling and Analysis Plan. If monitoring data are not provided for all COPCs, justification must be provided.

- Soil sampling and preparation must follow the procedures described in Appendix F of this guide.

Monitoring shall follow the quality assurance procedures provided in the section on Quality Assurance and Appendix E of this guide.

Reporting Final Site Status

As part of the cleanup process, the U.S. DOE will report the final site status to EPA and Ecology in the form of a Remedial Action Verification Package. DOH will use the data in this report to determine if the radiological cleanup criteria of this guidance have been met. The report must provide a complete and unambiguous record of the radiological status of the site relative to the RAOs. Sufficient information and data shall be provided to enable an independent re-creation and evaluation of both the survey activities and the derived results. The items that must be in the verification package or in readily available references to meet DOH requirements are as follows:

- Map of the site showing grid pattern and sampling locations.
- Table of monitoring results following the format of NUREG 5849, Sec. 8.4. This shall include data from the remediation area and also data on the material used for backfill.
- Information on measurement methods (survey instruments, *in situ* analytical equipment, analytical results from onsite or offsite laboratories) and calibration data.
- Historical or process data that were used to evaluate site status.
- If contamination extends below the 15 foot depth, provide an estimate of the concentrations of radionuclides that remain below that level and a basis for the estimate.
- Calculations of the dose to the RME individual who may occupy a site or facility. Provide description of the model or models used, along with the exposure scenarios, parameters and pathways. The soil concentration used for dose calculations shall be the upper confidence limit (UCL) 95% on the arithmetic mean soil concentration. Dose calculations for D&D facilities shall also be based on the UCL of radiation measurements.
- Quality assurance data

‘

Department of Health Review

Hanford cleanup may involve excavation of contaminated soil down to several feet (15 feet or more). The dose that could result from residual contamination left in place either at depth, on the surface, or on structures, must be evaluated to determine the dose to future occupants or users, the impact on groundwater, and the need for controls to prevent activities such as well drilling or deep excavation. Such evaluations will be based upon a variety of information sources, including characterization data, knowledge of site usage, process data and modeling. The final site status report (see section on Procedure) shall include dose calculations from all residual contamination that is either shallow, 0-15 feet or deep buried, >15 feet. It must also include the dose impact from any contamination contained in backfill material.

DOH will review the data and dose calculations provided in the final status report. It will perform additional dose calculations and conduct confirmatory surveys as needed to verify that the radiological RAOs have been met. When DOH has confirmed that the site meets the radiological RAOs, it will certify to Ecology that the radiological status of the site meets this guidance.

EXPOSURE SCENARIOS

Exposure scenarios are combinations of exposure pathways that are used to evaluate site risks or doses under different land-use classifications. The purpose of these scenarios is to ensure that all reasonable exposure pathways and assumptions are considered and that all individual exposures and risks are consistently and comprehensively assessed. The land-use classification to be used for Hanford cleanup will be determined through the cleanup process as described in the CERCLA ROD. When evaluating potential doses after cleanup, the agreed upon land use should be used with site-specific parameters.

Scenarios presented below were developed for the purpose of providing an example of how to use exposure scenarios as inputs to pathway models for calculation of cleanup concentration values and to calculate the dose from residual contamination following cleanup.

Unrestricted release of land is the most conservative land use scenario in that it allows land to be used for any purpose without restrictions. To evaluate this scenario, the impact of intrusion into deep buried contamination must be considered in addition to the other residential occupancy exposure. The following analysis shall be performed: Evaluate the dose to a resident, assuming a 6-inch diameter well is drilled to groundwater depth and that the volume of soil from the drilling is deposited over the ground surface in a circle 100 feet in diameter. Assume the parameters of the residential scenario. For unrestricted release, the dose from this scenario plus the dose from other residual radioactivity at the site must be below the 15 mrem/y dose limit.

The two exposure scenarios described below are Rural Residential (Unrestricted Use) and Commercial/Industrial.

Recreational land use has been proposed as a possible use for Hanford land. Recreational land use and potential doses from such land use are being looked at in detail by the current Columbia River Comprehensive Impact Assessment study, and it is envisioned that information from this study will provide a more comprehensive method of evaluating recreational scenarios. For this reason, a recreational scenario is not described in this guide.

Scenarios and recommended parameters for releasing D&D facilities are not included in this guidance and will be provided at a later date.

Rural Residential Exposure Scenario (Unrestricted Use)

The Rural Residential exposure scenario addresses long-term radiation dose to individuals expected to live on a site after cleanup. This is the most conservative scenario as it assumes that persons living on the site can use the land for any purpose without land-use restrictions. The assumptions are that the individuals live onsite and are exposed chronically, both indoors and outdoors, to residual concentrations of radionuclides in soil. It assumes that these individuals work primarily offsite and engage only in light farming and recreational activities onsite. It also assumes that a portion of the produce, meat, milk and fish consumed by the resident come from the site and can contain radioactivity from residual radionuclides in the soil. It assumes drinking water comes from an onsite well. The pathways for this scenario are listed in Appendix A.

Commercial/Industrial Exposure Scenario

This scenario addresses long-term radiation exposure to commercial or industrial workers exposed daily to residual levels of radionuclides in soil during an average work day onsite, both indoors and outdoors. This scenario does not consider exposures to site remediation workers or construction workers. Since worker exposures are limited to working hours and do not include contributions from ingestion of home-grown produce, meat, milk, or locally caught fish, doses to workers are expected to be consistently lower than those for individuals in the rural residential scenario.

PATHWAY MODELING

Applicable Models

Multipathway exposure models are used to evaluate the potential radiation dose to future occupants. Two modes of exposure must be evaluated to determine the impact of residual radioactivity. These are:

(1) exposure through onsite pathways (resuspension, onsite well, onsite food crops, soil ingestion, etc.) from the source to the on-site resident, and

(2) exposure that can occur as a result of contaminants being transported away from the site through groundwater pathways to an adjacent area or the Columbia River.

For evaluating doses through onsite pathways from residual radioactivity in soil (direct radiation, airborne particulates, ingestion of food, water, and soil), RESRAD, Version 5.61, is the recommended computer dose code. Further information on the code can be obtained from the *Manual for Implementing Residual Radioactive Guidelines Using RESRAD, Version 5.0* (Yu et al 1993).

For consistency of calculating doses, those RESRAD parameter values in Appendix B that are outlined and light shaded shall be used for all cleanup dose calculations. Other parameter should be from actual site-specific data, if available.

RESRAD has limited capability for evaluating the Hanford groundwater regime where contaminants can be transported through vadose and saturated zones to the Columbia River. A number of groundwater models have been used at Hanford to evaluate subsurface and surface water transport and the selection of the model or models to be used for this purpose is left to the TPA members: U.S. DOE, EPA, and Ecology. The dose assessment from the groundwater pathway that is reported in the Remedial Action Verification Package shall include rationale for the model used. Site-specific parameters shall be used when they are available.

Look-up Tables

An example look-up table included in Appendix C provides concentrations of radionuclides in soil that will result in a 15 mrem/y dose for the rural residential and industrial/commercial scenarios. The table was developed using RESRAD with the model parameters in Appendix B. The purpose of this table is to give an example of calculated soil cleanup concentrations that would meet the 15 mrem/y standard under various land uses. The concentrations listed in the table represent the dose when a single radionuclide is present and must be reduced proportionately (sum of fractions of radionuclide concentrations to dose standard concentrations must be less than 1) if multiple radionuclides are present. The parameters were selected from established references, Hanford specific data, and from regulatory agencies (EPA and NRC). They are considered to be realistic, but conservative parameters. Actual site evaluations should use the appropriate site-specific values when they are available except for the values that are outlined and shaded in Appendix B.

When cleanup is completed, a calculation of the dose that occupants of the remediated area could receive must also be performed using the measured residual contamination concentrations and the parameters for the proposed land use.

QUALITY ASSURANCE

Quality assurance (QA) is an essential element in every aspect of the radiological site cleanup. QA includes all the actions necessary to ensure that the radiological measurements, analyses, and calculations are valid and to provide a high level of confidence in the cleanup data. Because such data serve as the basis for determining whether cleanup objectives and radiological standards have been met, confidence in the quality of the numbers is crucial. In the end, public acceptance of the cleanup of the land rests on the credibility of the cleanup data. Quality assurance requirements are described in Appendix E.

Analytical results for radioactivity in soil are very dependent on the method used and the size fraction used for analysis. To provide uniformity in the monitoring results at Hanford, it is recommended that all soil sampling follow the protocol in Appendix F. No single method of soil sampling is applicable to all sample types and situations; therefore, three different methods are provided.

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APPENDIX A. *Exposure Pathways Assumed for Radiation Dose Calculations*

Exposure Pathways	Scenarios: Rural Residential	Scenarios: Commercial/ Industrial
External radiation exposure from gamma emitting radionuclides in soil	Yes	Yes
Inhalation of resuspended soil and dust containing radionuclides	Yes	Yes
Inhalation of radon and radon decay products from soil containing radium	No	No
Incidental ingestion of soil or sediment containing radionuclides	Yes	Yes
Ingestion of drinking water containing radionuclides transported from soil to potable groundwater sources	Yes	No
Ingestion of home grown produce contaminated with radionuclides taken up from soil	Yes	No
Ingestion of meat containing radionuclides taken up by cows grazing on contaminated plants	Yes	No
Ingestion of milk containing radionuclides taken up by cows grazing on contaminated plants	Yes	No
Ingestion of locally caught fish containing radionuclides	Yes	No
Ingestion of game meat containing radionuclides	No	No

APPENDIX B. *RESRAD Parameters Used for 15 mrem/y Soil Concentrations in Appendix C.* (Parameters in shaded boxes are to be used in all cleanup scenario calculations; for others, site-specific parameters should be used when available)

Parameter	Units	Rural Residential	Industrial Commercial	Reference/ Rationale
R02 Exposure Pathways				
Pathway 1-External Gamma		Active	Active	
Pathway 2-Inhalation		Active	Active	
Pathway 3-Plant Ingestion		Active	Suppressed	
Pathway 4-Meat Ingestion		Active	Suppressed	
Pathway 5-Milk Ingestion		Active	Suppressed	
Pathway 6-Aquatic Foods		Active	Suppressed	
Pathway 7-Drinking Water		Active	Suppressed	
Pathway 8-Soil Ingestion		Active	Active	
Pathway 9-Radon		Suppressed	Suppressed	
R011 Contaminated Zone (CZ)				
Area of CZ	m^2	10,000	10,000	RESRAD Default and approx. size of large Hanford Retention Basin
Thickness of CZ	m	4.6	4.6	15 ft.(4.6m) used in MTCA cleanup
Length Parallel to Aquifer Flow	m	100	NA	Approximate Diameter of CZ
Radiation Dose Limit	mrem/yr	15	15	Value used in this Guidance and in 100 Area ROD
Elapsed Time of Waste Placement	yr	0	0	RESRAD Default
R013 Cover and Cont. Zone Hydrological Data				
Cover Depth	m	0	0	No Cover Assumed
Density of Cover Material	g/cm^3	NA	NA	
Cover Erosion Rate	m/yr	NA	NA	
Density of CZ	g/cm^3	1.6	1.6	Hanford Specific DOE/RL-90-07
CZ Erosion Rate	m/yr	0.001	0.001	RESRAD Default
CZ Total Porosity		0.4	0.4	RESRAD Default
CZ Effective Porosity		0.2	0.2	RESRAD Default
CZ Hydraulic Conductivity	m/yr	250	250	Hanford Specific DOE/RL-96-11
CZ b Parameter		4.05	4.05	RESRAD Table-100N Soil Profile
Humidity in Air	g/cm^3	NA	NA	
Evaporation Coefficient		0.91	0.91	EPA Region X Guidance
Precipitation	m/yr	0.16	0.16	6.3 in. annual rainfall DOE/RL-90-07
Irrigation Rate	m/yr	0.76	0.76	EPA Region X Guidance
Irrigation Mode		Overhead	Overhead	RESRAD Default
Runoff Coefficient		0.2	0.2	RESRAD Default
Watershed Area for Nearby Stream or pond	m^2	1,000,000	NA	RESRAD Default
Accuracy for Water/Soil Computation		0.001	NA	RESRAD Default
R014 Saturated Zone (SZ) Hydrological Data				
Density of SZ	g/cm^3	1.6	NA	Hanford Specific DOE/RL-90-07
SZ Total Porosity		0.4	NA	RESRAD Default

APPENDIX B CONTINUED.

Parameter	Units	Rural Residential	Industrial Commercial	Reference/ Rationale
SZ Effective Porosity		0.2	NA	RESRAD Default
SZ Hydraulic Conductivity	m/yr	5530	NA	DOE/RL 96-11, DOE/RL-93-37
SZ Hydraulic Gradient		0.00125	NA	DOE/RL 94-136
SZ b Parameter		4.05	NA	RESRAD Table-100N Soil Profile
Water Table Drop Rate	m/yr	0.001	NA	RESRAD Default
Well Pump Intake Depth	m below water table	4.6	NA	Typical RCRA Screen Depth
Nondispersion or Mass Balance		Nondispersion	NA	
Well Pumping Rate	m^3/yr	250	NA	RESRAD Default
R015 Uncontaminated and Unsaturated Strata Hydrological Data				
Number of Unsaturated Strata		1	NA	Generic Site Model DOE/RL 96-17
Thickness	m	12	NA	Generic Site Model DOE/RL 96-17
Soil Density	g/cm^3	1.6	NA	Hanford Specific DOE/RL-90-07
Total Porosity		0.4	NA	RESRAD Default
Effective Porosity		0.2	NA	RESRAD Default
Soil-specific b Parameter		4.05	NA	RESRAD Table-100N Soil Profile
Hydraulic Conductivity	m/yr	250	NA	DOE/RL 96-11, DOE/RL-93-37
R016 Distribution Coefficients and Leach Rates				
Contaminated Zone K_d	cm^3/g	See Table	See Table	
Uncontaminated Zone K_d	cm^3/g	See Table	See Table	
Saturated Zone K_d	cm^3/g	See Table	See Table	
Saturated Leach Rate	/yr	0	0	
Saturated Solubility		0	0	
R017 Inhalation and External Gamma				
Inhalation Rate	m^3/yr	7300	7300	From EPA 1991
Mass Loading for Inhalation	g/m^3	0.0001	0.0001	From Schreckhise et. al.
Dilution Length for Airborne Dust	m	3	3	RESRAD Default
Exposure Duration	yr	30	25	RESRAD Default
Inhalation Shielding Factor		0.4	0.4	RESRAD Default
External Gamma Shielding Factor		0.8	0.8	From EPA 1991
Indoor Time Factor		0.6	0.22	From EPA 1989
Outdoor Time Factor		0.2	0.014	From NUREG -5512
Shape Factor		1	1	RESRAD Default
R018 Ingestion Pathway Data, Dietary Parameters				
Fruits, Vegetables, and Grain Consumption	kg/yr	110	NA	DOH calculated from EPA and NRC Refs.
Leafy Vegetable Consumption	kg/yr	2.7	NA	From NUREG-5512
Milk Consumption	L/yr	100	NA	From NUREG-5512
Meat and Poultry Consumption	kg/yr	36	NA	Based on 75 g/d beef from EPA 1989 and 9 kg/y poultry from NUREG 5512
Fish Consumption	kg/yr	5.4	NA	RESRAD Default
Other Seafood Consumption	kg/yr	NA	NA	
Soil Ingestion	g/yr	36.5	36.5	RESRAD Default
Drinking Water Intake	L/yr	730	NA	EPA SDWA

APPENDIX B CONTINUED.

Parameter	Units	Rural Residential	Industrial Commercial	Reference/ Rationale
Drinking Water Contaminated Fraction		1	NA	RESRAD Default
Household Water Contamination fraction		NA	NA	RESRAD Default
Livestock Water Contamination Fraction		1	NA	RESRAD Default
Irrigation Water Contamination Fraction		1	NA	RESRAD Default
Aquatic Food Contamination Fraction		0.5	NA	RESRAD Default
Plant Food Contamination Fraction		-1	NA	RESRAD Default
Meat Contamination Fraction		-1	NA	RESRAD Default
Milk Contamination Fraction		-1	NA	RESRAD Default
R019 Ingestion Pathway Data, Nondietary				
Livestock Fodder Intake for Meat	kg/day	68	NA	RESRAD Default
Livestock Fodder Intake for Milk	kg/day	55	NA	RESRAD Default
Livestock Water Intake for meat	L/day	50	NA	RESRAD Default
Livestock Water Intake for Milk	L/day	160	NA	RESRAD Default
Livestock Intake of Soil	kg/day	0.5	NA	RESRAD Default
Mass Loading for Foliar Deposition	g/cm^3	0.0001	NA	RESRAD Default
Depth of Soil Mixing Layer	m	0.15	NA	RESRAD Default
Depth of Roots	m	0.9	NA	RESRAD Default
Groundwater Fractional Usage-Drinking Water		1	NA	RESRAD Default
Groundwater Fractional Usage-Household Usage		NA	NA	RESRAD Default
Groundwater Fractional Usage-Livestock Water		1	NA	RESRAD Default
Groundwater Usage-Irrigation		1	NA	RESRAD Default
R021 Radon				
Radon Parameters Not Used				

NA indicates that a parameter was not applicable and not used because of the scenario selected. Irrigation that is indicated for the Industrial scenario is assumed for landscape irrigation.

APPENDIX B CONTINUED.

Summary of Distribution Coefficient Values (K_d)

Radionuclide of Concern	Recommended Value	
Am-241	200	Ames and Serne, 1991
Co-60	50	“
Cs-137	50	“
Eu-152	200	“
Eu-154	200	“
Pu-239	200	Serne and Woods, 1990
Sr-90	25	Ames and Serne, 1991
Tc-99	0	Serne and Woods, 1990
Uranium	25	Based on Review of References

The distribution coefficient, K_d, is a partitioning coefficient under equilibrium conditions that assumes a linear relationship between the concentration of a solute in the soil (Cs) and the liquid (Cw) phases; that is $C_s=k_dC_w$. It is used in models to determine movement and concentrations of pollutants in groundwater. It is an empirical parameter that represents the tendency for a chemical substance to absorb to soil. The greater the extent of adsorbtion in soil, the greater the K_d.

APPENDIX B CONTINUED.

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APPENDIX C. *Soil Concentrations That Will Result in a 15 mRem/y Annual Dose*

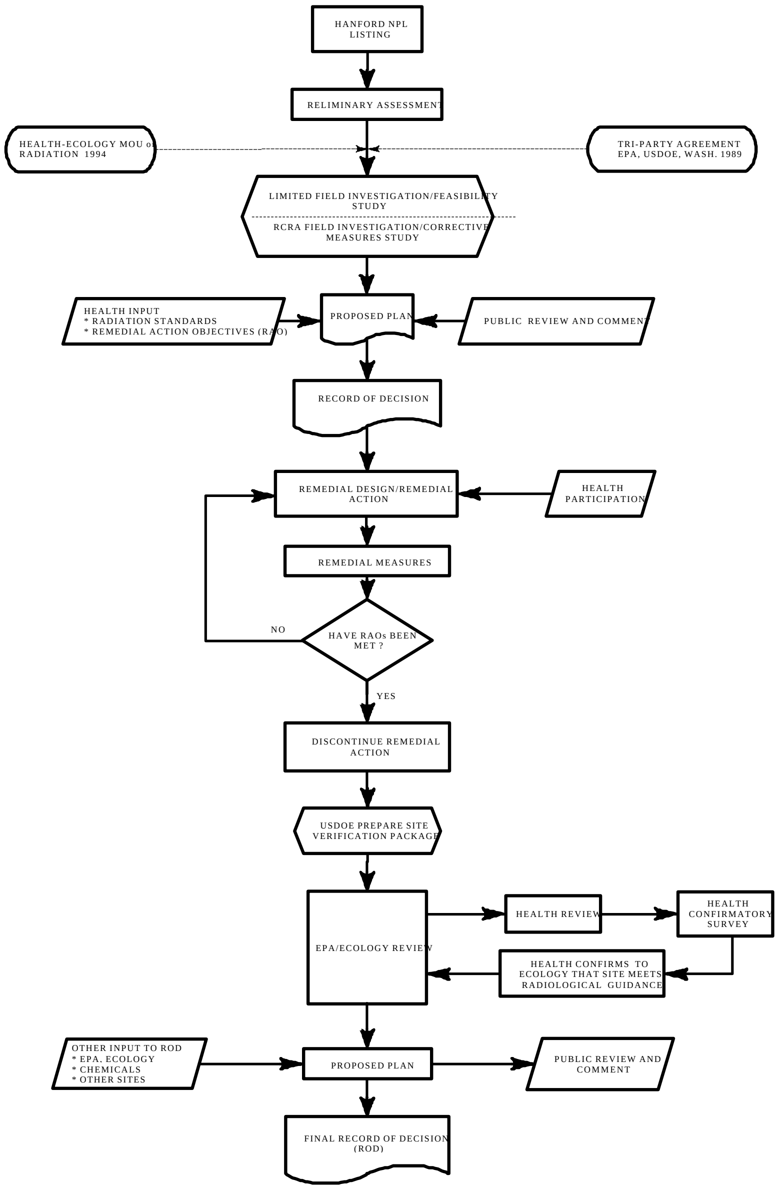
Concentrations (pCi/g) of residual radionuclides in soil that individually will result in an annual total effective dose equivalent of 15 mrem/y to the RME (using RESRAD Version 5.7, January 1997) and parameters in Appendix B. This type of table must be generated for each site-specific situation.

Radionuclide	Rural Residential (pCi/g)	Commercial/ Industrial [no groundwater] (pCi/g)
Am-241	31	210
Co-60	1.4	5.2
Cs-137	6.2	25
Eu-152	3.3	12
Eu-154	3.0	11
Pu-239	34	245
Sr-90	4.5	2500
Tc-99	5.7	4.1E+05
U-234	160	1200
U-235	26	100
U-238	85	420

For mixtures of radionuclides, the following criteria must be met:

Concentration of Nuclide A/Guide Concentration A + Concentration of Nuclide B/Guide Concentration B + ···· ≤1

APPENDIX D. *Flow Diagram of the Washington Department of Health Involvement in the Hanford Cleanup Process*



APPENDIX E. *Quality Assurance*

Quality Assurance (QA) is defined as "planned and systematic actions" necessary to (1) provide confidence in the results of a monitoring or measurement program, and (2) ensure the accuracy of techniques and analyses. QA is an important part of the Hanford cleanup efforts because confidence in the overall effectiveness and adequacy of the cleanup rests on the quality of radioactivity measurements and sample analyses. The QA measures prescribed for compliance with this guide are listed below.

I. SAMPLING AND FIELD MEASUREMENTS

The instrument used for field measurements shall be periodically maintained and calibrated. The instrument shall be calibrated to radionuclides of the same types and energies as the radionuclides of interest on the site. The calibration frequency shall be appropriate with the operating history of the instrument and consistent with manufacturer's recommendations and Hanford standard practice. The radioactivity standards used for calibration shall be traceable to the National Institute of Standards and Technology (NIST). Check sources may be used to check instrument operation between calibrations. Calibration of field instruments shall incorporate corrections for angular response and any other condition affecting the instrument results, such as temperature, humidity, vibration, or interferences from background radiation.

Sampling is the first step in obtaining analytical data on radionuclides in the environment. The QA for sampling shall be of the same quality and rigor as that applied to field and laboratory measurements.

- Personnel conducting sampling and field measurements shall be trained and periodically retrained in the procedures.
- Sampling and field measurements shall be performed according to written procedures.
- The integrity of samples shall be maintained by adequate packaging, labeling, and chain of custody.
- All field measurements shall be documented and reported. The units of all measurements shall be clearly stated and reported with the measurement results.
- Protocols shall be established for identifying when field measurements are anomalous and procedures shall be established for resolving the anomalous data.
- Records for field measurements shall be accurate, readily retrievable and protected from damage.

APPENDIX E CONTINUED.

II. LABORATORY ANALYSES

The QA program elements required for laboratories conducting analysis of Hanford site samples are:

A. Organizational Structure and Management Commitment

- Personnel shall be adequately trained, qualified and knowledgeable.
- The responsibilities and authorities of each employee shall be identified.
- Those employees involved with QA functions shall have organizational authority to identify and resolve problems and recommend or implement solutions.
- The effectiveness of the QA program shall be periodically reviewed.

B. Procedures and Instructions.

- Written procedures shall be prepared for all monitoring activities associated with the cleanup.
- All procedures shall be reviewed by a qualified and knowledgeable individual.
- Analytical procedures shall be standard procedures, such as those of the American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), the U.S. Department of Energy's Environmental Measurements Laboratory (EML-HASL-300), Environmental Protection Agency (EPA), or some other generally accepted source.

C. Laboratory Records and Reporting

Sufficient records shall be kept to maintain the ability to track and control a sample or instrument measurement from the point at which it is taken to the reporting of the final results. Such records shall include bench and field log books.

Laboratory quality control records shall include: radioactive check and calibration results, background measurements, blanks, duplicates, replicates and spiked samples, intralaboratory and interlaboratory performance testing, control charts, trending analyses, graphs of results, instrument performance, calibration and maintenance records.

Other quality assurance records include: personnel training and qualification, data reports and summaries, results of audits, standard preparation, calibration and methods.

- All records shall be accurate, readily retrievable and protected against damage, loss or deterioration.

APPENDIX E CONTINUED.

- All sampling, measurement and analytical records shall be kept indefinitely.

- The verification of computer programs and calculations of detection and control limits shall be documented in the quality control records.

D. **Quality Control**

- Calibration schedules shall be appropriate with the operating history of the instruments and consistent with manufacturer's recommendations and Hanford standard practice.

- Calibration frequency shall be at least annually, or according to the manufacturer's recommended frequency, whichever is more frequent. The operating history of the instrument shall also be considered.

- Radiation standards used for instrument calibration shall be traceable to NIST.

- Background measurements shall be done on each instrument daily or before each use, except in the case of long sample counts where backgrounds shall be counted at least monthly for the same length of time as samples. Blank samples shall be counted with each batch of field samples.

- Check sources shall be counted daily or before each use to check each instrument's calibration.

- Control samples made up from the same or similar material as routine field samples, and containing radioactivity at approximately the same concentration as field samples, shall be counted with each batch of field samples.

- The laboratory analyzing cleanup samples shall participate in intralaboratory and interlaboratory performance testing. Intralaboratory performance testing consists of blind, spiked, replicate and duplicate sample, submitted at a frequency of at least one per quarter. The laboratory shall participate in the EPA or EML intercomparison programs. The laboratory shall also split samples with other agencies and take side-by-side *in situ* measurements with other agencies, when possible.

- At least 10% of the samples analyzed shall be quality control samples.

- Samples shall be handled and stored in a way that preserves their integrity and prevents loss, spoilage or contamination. Samples shall be analyzed in a timely manner after collection.

- The results of QC samples and background measurements shall be documented on control charts and compared to limits of acceptability.

APPENDIX E CONTINUED.

- Results generated during the performance of Hanford cleanup shall be independently verified and validated by a qualified individual, other than persons routinely responsible for the results.

- All computer programs shall be documented and independently verified by a qualified individual before initial use and after any subsequent modifications.

E. <u>Reporting Results</u>

- All analytical results shall include an estimate of their overall uncertainty. This overall uncertainty shall include counting errors and all other known sources of error.

- All analysis results shall be reported. All results shall be used in deriving data summaries and averages, except in the case of results believed to be invalid. In such cases, the data shall be flagged and the reasons for their exclusion shall be clearly documented.

- The units of measurement for analytical results shall be clearly stated and reported with the results. Actual results shall be reported, including negative data and data below detection levels.

- Detection limits and levels of concern or warning levels shall be determined for laboratory measurements. Protocol shall be established for handling analytical results which exceed control, warning, regulatory or other limits.

6. <u>Audits</u>

- Audits of the analytical laboratory programs shall be conducted on a periodic basis.

- Technical and QA audits shall be thorough reviews of the program compliance to applicable regulations, standards and acceptable operating practices.

- The results of the audits shall be reviewed by management of the areas audited.

- Corrective actions resulting from the audits shall be completed in a timely manner.

APPENDIX E. REFERENCES

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APPENDIX E CONTINUED.

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APPENDIX F. *Soil Sampling Methods for use in Site Radiological Cleanup*

The following methods are suitable for sampling soil for subsequent radiological analysis. No single method of gathering samples is adequate for all soil types encountered at all locations; therefore, three methods are described to cover the different situations.

For any of the three methods it is recommended that five samples be collected and composited into a single sample for each sampling location.

A. Cookie Cutter Method

The cookie cutter method is an appropriate means of taking soil samples when there are very few rocks and the soil is moist enough to be cohesive. A fine spray from a spray bottle has been used to provide moisture for non-cohesive dry soil. If this technique is used, it is recommended that several minutes elapse between application and sampling to allow for equilibration of moisture.

1. Place the cookie cutter (10.8 cm diameter x 2.5 cm depth) on the selected location and press it into the soil until it is flush with the surface. If more force is needed, this may be accomplished by stepping on the edges of the cookie cutter with both heels or a rubber mallet may be used.

2. Hold the cookie cutter and use the trowel to excavate the dirt away from the outside perimeter of the cookie cutter.

3. Slide the trowel under the cookie cutter so that the soil is cut off at the lower edge of the sampler.

4. Lift the cookie cutter and the trowel simultaneously. Trim the excess soil so that it is flush with the bottom of the sampler.

5. Empty the contents of the cookie cutter into the plastic bag.

6. Duplicate steps 1 through 5 at each of the remaining four locations and combine all recovered materials into one composite sample.

B. Trench Method

The trench method is the recommended technique appropriate for gravely soils. This method employs the use of a three-sided tray with a cutting edge (15 cm x 15 cm x 2.5 cm). Larger scoops are not as susceptible to interferences caused by stones and the edge of the sampling tray as it travels through the soil. It is also the recommended method for measuring the vertical distribution of radioactivity in the soil.

Construct a rectangular trench adjacent to the spot to be sampled that is a least 15 cm to 25 cm deeper than the sampling depth. The desired sampling edge of the trench is smoothed off perpendicular to the surface using a trowel or a shovel.

APPENDIX F CONTINUED.

1. The cutting edge of the tray is placed against the sampling edge of the trench and pushed until the top edge of the tray is flush with the surface of the ground.

2. The trowel or flat blade shovel is placed against the open cutting edge of the tray to prevent its contents from spilling.

3. Excavate the soil outside the tray to the depth of the tray.

4. Remove the tray and dump the contents into the plastic sample bag. A soil sample contains soil to a minimum depth of 2.5 cm.

5. Duplicate steps 1 through 4 until the desired depth is reached, taking care to avoid cross-contamination between layers.

6. Duplicate steps 1 through 4 at each of the remaining four locations and combine all recovered materials into one composite sample.

C. Template Method

The template method is preferred where rocky soils make it impossible to use the cookie cutter or trench methods of soil sampling.

1. Using the "template" as a guide, mark out an area of 100 cm^2 using the knife, shovel or trowel.

2. Remove the "template" and scoop out the material to the desired depth. A soil sample contains soil to a minimum depth of 2.5 cm.

3. Duplicate steps 1 and 2 at each of the remaining four locations and combine all recovered materials into one composite sample.

Sample Preparation

Roughly, 1 to 2 kilograms of sample will comprise the amount needed for analysis by the laboratory.

It is recommended that all soil samples be sieved with a one-quarter inch sieve. The portion passing the quarter inch sieve will be used for radiochemical analysis and the weight of this portion shall be considered the sample weight. In most cases, samples will not be sieved in the field but rather at a field laboratory or at the analytical laboratory.